DESIGN IMPROVEMENT OF THE ASSEMBILITY AND DISASSEMBILITY OF INTEGRATED TABLE, RACK AND WARDROBE (TRW)

NUR FARHANA BTE MUSTAFFA

UNIVERSITI MALAYSIA PAHANG

UNIVERSITI MALAYSIA PAHANG

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(TANDATANGAN PENYELIA)

Alamat Tetap:

No. 39 Kg Kuala Nau,
09020 Kulim
Kedah

MOHAMED REZA ZALANI MOHAMED SUFFIAN
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DESIGN IMPROVEMENT OF THE ASSEMBILITY AND DISASSEMBILITY OF INTEGRATED TABLE, RACK AND WARDROBE (TRW)

NUR FARHANA BTE MUSTAFFA

A report submitted in partial fulfilment of the requirements
for the award of the degree of
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JUNE 2008

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing.

Name of Supervisor: MR. MOHAMED REZA ZALANI BIN MOHAMED SUFFIAN
Position: UNIVERSITY LECTURER
Date: 6 NOVEMBER 2008

Name of Panel: MR. ZAMRI BIN MOHAMED
Position: UNIVERSITY LECTURER
Date: 6 NOVEMBER 2008

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurently submitted for award of other degree.

Name: NUR FARHANA BTE MUSTAFFA
ID Number: ME05036
Date: 6 NOVEMBER 2008

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ABSTRACT

In UMP, the student's room is cramped with individual product such as study table and wardrobe that causing the limited living space. In order to overcome this, the table, rack and wardrobe (TRW) are proposed to be one unit from three separate units. This paper is aim to proposed a framework of the *integrated design*. The design concept is aim to apply by adopting the principle of *Design for Assembly (DFA) and Design for Disassembly (DFD)* concept. The product design properties such as mechanical strength and stress will be analyzed by using the Finite Element Method (FEM). The Pugh Method then is used and it is aim to select the best alternative based on the DFA, DFD and FEM criteria. Afterwards, the fabricating process is done by using punching and bending machine. The consequences of applying all the analysis mentioned to the product are in order to create a better quality and reliability of the product and also improving customer satisfaction.

ABSTRAK

Di UMP, bilik pelajar selalunya dipenuhi dengan produk individu seperti meja belajar dan almari pakaian yang menyebabkan kesesakan ruang hidup. Bagi mengatasi masalah ini, meja belajar, rak dan almari pakaian (TRW) dicadangkan untuk dijadikan satu unit produk yang berasal dari tiga unit berasingan. Kertas kerja ini bertujuan bagi mencadangkan rangka kerja *gabungan rekaan produk*. Konsep rekaan adalah bertujuan untuk mengaplikasikan prinsip-prinsip *Rekabentuk Untuk Penyatuan (DFA) dan Rekabentuk Untuk Pengasingan (DFD)* konsep. Sifat-sifat konsep produk seperti kekuatan mekanikal dan stress akan dianalisis menggunakan FEM. Kaedah Pugh kemudian digunakan dan ianya bertujuan bagi memilih alternatif terbaik berdasarkan DFA, DFD dan FEM kriteria. Selepas itu, proses pembuatan produk ini dijalankan dengan menggunakan mesin penebuk dan membengkok. Kesan kepada produk setelah analisis-analisis yang dinyatakan dilakukan terhadap produk adalah dibuat bagi mencipta sesuatu produk yang mempunyai kualiti serta daya ketahanan yang baik di samping memenuhi citarasa pelanggan.

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LIST OF ABBREVIATIONS

TRW	Table, Rack and Wardrobe
DFA	Design for Assembly
DFD	Design for Disassembly
DIY	Do-It-Yourself
DFMA	Design for Manufacturing Analysis
FEM	Finite Element Method

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter discussed the background of the project, the objective, scopes, the expected output and the structure of the thesis.

1.2 BACKGROUND

Integrated product design is defined as combination of more than two products into a multifunctional product. As a population increase, the demand for a living space is automatically increased. Therefore, a result of an increasing cost for building material. The increasing of building material would affect and reduce the living spaces. As consequences, the limited space such as living room and bedroom occurs.

This encourages the compact and integrated design of household products. Book rack, wardrobe and study table are among the important household item. These current products are separate and occupy large space that would arouse an inconvenience in living environment.

In UMP, each room accommodates four students. There would be four times furniture of an average person has in one room. The furniture certainly occupied most of the space in that room and limits the living space the students needs. Therefore a compact and integrated TRW (Table, Rack and Wardrobe) are more preferable to maximize the living space especially in UMP hostel where all students lived.

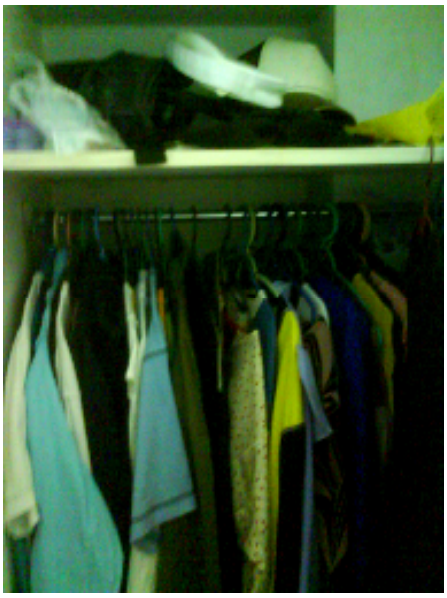

Figure 1.1: Current wardrobe at UMP hostel.

Figure 1.2: A wooden rack that is bought by students since it is not provided.

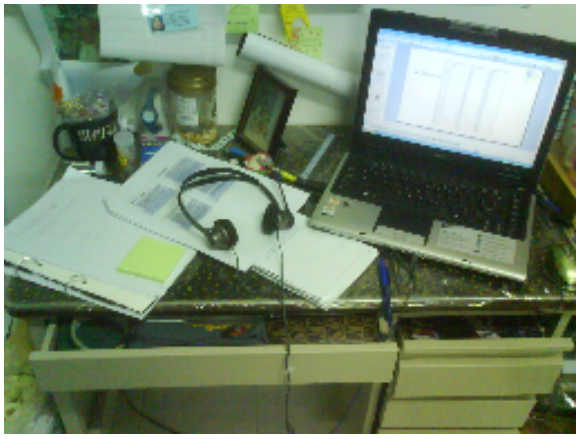

Figure 1.3: Current table in the UMP hostel.

This project is aim to increase the space of room in product design perspective without sacrificing the original function of the products.

1.3 PROBLEM STATEMENT

1. A design improvement of integrated product must be created with the aim to increase the living space.

2. The products parts must be easy to dissemble and assemble (DIY concept) with minimum parts required to assembled.

1.4 OBJECTIVE

The objective of this project is to design a compact and integrated table, rack and wardrobe with a Do-It-Yourself (DIY) concept by adopting the Design for Assembly (DFA) and Design for Disassembly (DFD) principles.

1.5 PROJECT SCOPE

In order to achieve the objective above, the following scopes are identified.

1. Literature review through various sources to help describe the integrated product design.
2. Survey is done within UMP students.
3. Pugh method will be used in selecting the design alternatives.
4. The software will be use is Solidwork for modeling.
5. ALGOR will be use for stress and strain analysis on the product.
6. Trump 300 & 600 is use for modeling the design sheet metal before analysis prototype fabrication.
7. Punching and bending machine will be used in prototype fabrication process.

1.6 PROJECT STRUCTURE

This report is divided according to the chapters below:

1. Chapter 1 - This chapter discusses about overall introduction of the project. This includes project background, problem statement, objectives and project scope.
2. Chapter 2 - This chapter described about literature review of the project. This chapter reviews on articles that relates to integrated product, Design for Assembly (DFA) and disassembly (DFD), Pugh

method and review of few comparison of table, rack and wardrobe (TRW).

3. Chapter 3 - This chapter explains to implement the methods of the project. A flow chart is used to describe the overall flow of the project.
4. Chapter 4 - This chapter discusses the results of the project. This includes the results of the survey had been done and the DFA results before and after modification and also the proposed design.
5. Chapter 5 - This chapter states the conclusion and future works. The outcome of this project will be concluding with some recommendation for the future.

1.7 CONCLUSION

This chapter described about the overall introduction of this project. Firstly, the detail of the background of this project is discussed. Then, problem statement is identified. After that, the objectives and project scopes is determined. Then the structure of the each project of the project is briefly described.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discusses the literatures of the integrated product, Design for Assembly (DFA) and disassembly (DFD), Pugh method and also reviews of table, rack and wardrobe (TRW) designs.

2.2 INTEGRATED PRODUCT DESIGN

Design is defined as a process whereby the human powers of creativity, conception and action are used to improve life, industry and nature. It is a generic term for activities involving the use of imagination and creativity to improve the quality of human life by modifying our surroundings and deliberately adapting various factors as an integrated whole (Keio University, 2007).

Therefore the aim is designing is to create not only individual products, but also engineering systems into which those products can be optimally fitted or in other words integrated products.

The quality of design will be measured not only in terms of functionality and ease of use, but also on the basis of environmental considerations, including the degree of impact on the global environment, and ease of recycling. Such considerations were not adequately addressed by the science and technology of the 20th century.

2.3 DESIGN FOR ASSEMBLY (DFA)

DFA is a process for improving product design for easy and low-cost assembly, focusing on functionality and on assemblability concurrently. It entails for making attachment directions and methods simpler, for example making a part easy to attach by using snap fits instead of machine screws. DFA involves application of attachment time and complexity models whether they are basic rules, table based on simplified time studies of full time and motion industrial engineer studies.

DFA is a systematic methodology that reduces manufacturing costs by reducing the total number of individual parts in a product and redesigning the remaining parts in the product for ease of handling and insertion (G. Boothroyd, P. Dewhurst and W. Knight, 1994). The DFA is a two-step process. The first process is to evaluate the assemblability of the individual parts as to whether the parts are easy to assemble or not. The second process is to evaluate the theoretical minimum number of parts that should be in the product. In the first process the rating system, such as the DFA Toolkit are use to evaluate each individual part with respect to (G. Boothroyd, P. Dewhurst and W. Knight, 1994):

1. Graspability—to check that the part is easy to be grasped or not during the period of assembly.
2. Orientability—to check if the part is easy to be oriented or not when it is being assembled.
3. Transferability—to check whether the part is easy to be transferred to the work position or not.
4. Insertability—to check if the part is easy to be inserted into the correct position or not when it is being assembled.
5. Securability—to check whether the part or the product is secure or not after the part has been assembled.

At the second process, theoretical minimum number of parts is evaluated by the part redundancy criteria. The following three questions about each part were asked:

1. does it move relative to adjacent parts,
2. do adjacent parts need to be made of a different material, and
3. does the part need to be separate to permit assembly or disassembly?

A "no" answer to all three questions recognizes that there is a high probability that the part can be eliminated through redesign. Elimination of extraneous parts always improves assemblability. If the assembly contains sub-assemblies treat them as "parts" and assign an identification number to each item, then analyze the sub-assemblies later with the above method.

Below is the summary of DFA guidelines:

1. Minimize the number of parts
2. Standardize and use as many common parts as possible
3. Design parts for ease of fabrication (use castings without machining and stampings without bend)
4. Minimize the number of assembly planes (Z-axis)
5. Use standard cutters, drills, tools
6. Avoid small holes (chips, straightness, debris)
7. Use common datum's for tooling fixtures
8. Minimize assembly directions
9. Maximize compliance; design for assembly
10. Minimize handling
11. Eliminate adjustments
12. Use repeatable, well understood processes
13. Design parts for efficient testing
14. Avoid hidden features
15. Use Guide features
16. Incorporate symmetry in both axis
17. Avoid designs that will tangle.
18. Design parts that orient themselves (Vincent C. and Filippo A.S., 2005).

2.4 DESIGN FOR DISASSEMBLY (DFD)

DFD is defined as a systematic method for separating a product into its constituent parts, components, subassemblies, or other groupings for several reasons (Lambert & Gupta, 2005). One of the reasons for disassembly is to carry out maintenance-related activities. Either a simple product or a complicated machine may be disassembled partially for the purpose of repair or periodic maintenance. Until a decade ago, many people believed that this is the only purpose of disassembly. However, with the realization of environmental problems including the alarming rate of diminishing resources, the concept of product recovery has captured the attention of a lot of governments, companies, researchers as well as the general public (Gungor & Gupta, 1999).

2.5 PUGH METHOD

This method is use as minimal evaluation scale and three overall ranking metrics. Pugh charts are the most effectives known tools for preliminary concept selection when there is minimal information quantity available. They are also effective as the information quality increases and the selection scale is refined. The goal of any selection process is to obtain as mush information and concept details as cycle time and resources permit.

2.5.1 Steps to Use/Construct Pugh matrix:

1. Choose or develop the criteria for comparison.
   - Examine customer requirements to do this.
   - Generate a set of engineering requirements and targets.

2. Select the Alternatives to be compared.

The alternatives are the different ideas developed during concept generation. All concepts should be compared at the same level of generalization and in similar language.

3. Generate Scores.

Usually designers will have a favorite design, by the time it comes to pick one. This concept can be used as datum, with all the other being compared to it as measured by each of the customer requirements. If the problem is to redesign an existing product, then the existing product can be used as the datum. For each comparison the product should be evaluated as being better (+), the same (S), or worse (-).

4. Compute the total score

- Four scores will be generated, the number of plus scores, minus scores, the overall total and the weighted total.
- The overall total is the number of plus scores- the number of minus scores.
- The weighted total is the scores times their respective weighting factors, added up.
- The totals should not be treated as absolute in the decision making process but as guidance only.
- If the two top scores are very close or very similar, then they should be examined more closely to make a more informed decision.

Table 2.1: General Format for a Pugh Matrix

Criteria	Concepts			
	Sketch of datum	Sketch of B	Sketch of C	Sketch of D
Criteria 1	D			
Criteria 2	A			
Criteria 3	T			
$\Sigma+ (P_i)$	U			
$\Sigma- (N_i)$	M			
Σ	0			

Source: Edward Lumsdaine and Monika Lumsdaine (2006)